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The role of *Ulmus laevis* in German floodplain landscapes

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Abstract

In the past, the spread of modern civilisation has heavily reduced the occurrence of natural woodlands in floodplain landscapes and the numbers of elms have also been reduced on a large scale. At the time of the outbreak of Dutch elm disease (DED), the elm populations may have already been reduced by an estimated 90%. At that time, *Ulmus minor* was the most common elm species in the riparian forests of lowland Central Europe. Eighty years later, the numbers of *U. minor* had decreased significantly. Data from three rivers in Saxony, Germany suggest that a further 90% of the trees have succumbed to DED. The survivors have mostly been reduced to shrubs and small trees. *Ulmus laevis* has taken over the role of the typical and well established elm species in floodplain landscapes. Being less susceptible to DED, the trees dominate parts of floodplain meadow landscapes and riparian forests. However, the overall number is low when compared with other tree species. Most *U. laevis* trees find only restricted habitats within agricultural landscapes and in many cases the elm itself is the only reminder of the existence of a former riparian wildwood. Also, some individuals show a high degree of crown transparency without having been infected with DED. If elms are to constitute an important part of the floodplain tree flora in the future, it is crucial to protect and enhance the existing *U. laevis* populations. Controlled provenances can help in the process of re-establishing floodplain forests.

Key words: *Ulmus minor,* riparian forest, hemerobis, Dutch elm disease

Resumen

El papel de *Ulmus laevis* en las llanuras fluviales en Alemania

En el pasado, el desarrollo de la civilización moderna ha reducido intensamente la presencia de la vegetación natural en zonas aluviales, y como consecuencia de ello el número de olmos se ha visto también reducido en gran escala. En el momento de la aparición de la grafiosis, la población de olmos podía ya haberse visto reducida en un aproximadamente 90%. En ese momento, *Ulmus minor* era la especie más común de olmo en los bosques aluviales de Europa Central. Ochenta años más tarde, el número de *U. minor* ha disminuido significativamente. Los datos procedentes de tres ríos en Sajonia, Alemania, sugieren que más del 90% de los árboles han muerto como consecuencia de la grafiosis. Los supervivientes se han visto reducidos a arbustos y pequeños árboles. *Ulmus laevis* se ha convertido en el olmo de zonas aluviales más típico y mejor establecido. Al ser menos susceptible a la grafiosis, esta especie es dominante en parte de los paisajes aluviales y de los bosques riparios. Sin embargo, el número total es bajo comparado con otras especies arbóreas. La mayor parte de los individuos de *U. laevis* se encuentran en áreas restringidas dentro de zonas agrícolas mayores, y en muchos casos el olmo en sí es el único recuerdo de la existencia de un antiguo bosque de ribera. Además, algunos individuos presentan una baja densidad de follaje pese a no estar afectados por la grafiosis. Si los olmos han de constituir una parte importante de la vegetación aluvial en el futuro, resulta crucial proteger y mejorar las poblaciones existentes de *U. laevis*. Las procedencias controladas pueden ayudar en el proceso de restablecer los bosques aluviales.

Palabras clave: *Ulmus minor,* bosque de ribera, hemerobis, grafiosis.

Introduction

Rivers, floodplains, riparian forests and their biological communities have lived through enormous changes ever since they came into existence after the last Ice Age. When human civilisation began in Central Europe some 6,500 years ago, the natural forest cover slowly turned into semi-natural wildwood. Softwood riparian forests, mainly consisting of various species of *Salix*, *Populus* and *Alnus*, developed close to the river water line. Typical hardwood riparian forests established themselves at slightly higher elevations which are less prone to periodic flooding. The main tree genera are *Ulmus*, *Fraxinus* and *Quercus*. Before DED, *U. minor* (field elm) and *U. laevis* (white elm)

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were two of the most dominant species in riparian forests in most parts of lowland Germany.

The situation changed little for several centuries because the floodplain was not used much for agriculture and the rivers were as yet an untamed natural force. The river landscapes entirely changed their character with the increasing demand for arable land and pastures (especially in the Middle Ages), the growth of towns and cities, the need to use rivers as waterways for transportation, the development of streets and eventually railway lines and the human struggle against uncontrolled floods. What was once close to a wilderness became a fully manmade cultivated landscape. Today, most floodplain landscapes are far from being in their original state. Behind the embankments, there are maize cultures stretching to the horizon, cattle graze near the rivers, settlements extend far into the inundation areas, bridges span the rivers and locks and dams control the water. The forestry industry has transformed the woodlands located at the higher elevations with poorer soils into conifer forests.

All the major lowland rivers and streams have lost most of their natural habitats, including both the softwood and hardwood forests. In the case of the latter, an unknown but huge number of elms have vanished for ever. As a guess, one could say that approximately 90% of the elms in these regions have been lost due to human activities – that is to say, prior to the advent of DED. The disease has subsequently caused the death of another 90% of the remaining trees, so that today we probably see no more than a mere 1% of the original elm populations in floodplain landscapes.

This paper will endeavour to give the reader an idea of the structure of the elm populations along some of the rivers in lowland Saxony and the effects of DED. Furthermore, the unique position of *U. laevis* will be highlighted. The concept of hemerobis will be used to describe and define the surviving elm habitats in the context of the overall landscape changes.

Materials and Methods

A comprehensive study of the genus *Ulmus* was carried out in Saxony from 1995 to 1999. The results have been published both in German and in English (Mackenthun, 2000a, b). This paper presents the figures from the original study combined with a new approach towards landscape description and evaluation. The problem of crown transparency is also addressed in more detail. As far as we know, the concept of hemerobis (Jalas, 1955; Sukopp, 1976; Steinhardt *et al.*, 1999) has been used here for the first time in the context of elm ecology. Therefore, the idea behind and the application of the hemerobis concept is described below in more detail than is the case for the other methods used.

The original study concentrated on the Bundesland of Saxony in the southern part of East Germany. An overall number of 156 plots were investigated. The 34 plots situated in the lowland region of Saxony have been selected for this new study. Plots with an area of 20 ha each were established every 5 km along the floodplains of the Elbe, Mulde and Spree (for an example, Fig. 1). The elms were identified (Mackenthun, 1997), counted and measured for their diameter at breast height and tree height, while their degree of crown transparency was also estimated (see Mackenthun 2000a for details).

The crown transparency was estimated using a key developed for the evaluation of forest decline (Bos-

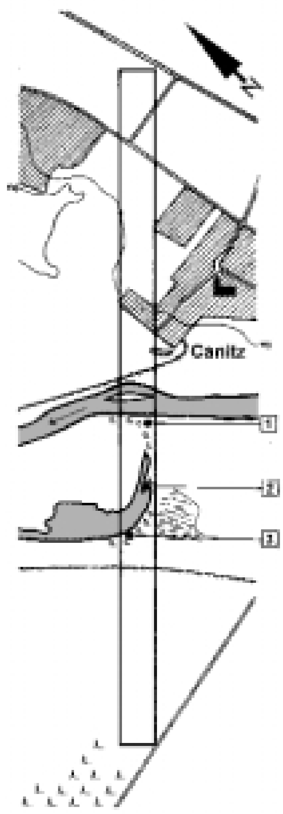

Figure 1. Map of a typical plot. Corresponds to plot M 105 at the river Mulde near the village of Canitz (110 m). The plot itself is the central rectangle (2,000 × 100 m). The main channel of the river is in the middle, above it is a very small lake, below it is a dead arm and an adjacent swamp. At the bottom of the map is a conifer forest. The village area is hatched. Elms occur only in semi-natural habitats close to the water lines, all three of them are *U. laevis*.

sard, 1986). With a certain degree of caution, crown transparency may be used as a term to express the overall vitality of a tree. The method is widely used all over Europe, though the concept has its drawbacks and the reasons for crown transparency are as yet not fully understood (Innes, 1990).

In 2002, 18 *U. laevis* trees with differing degrees of crown transparency from known locations were tested for fungal wood pathogens in their branches. The laboratory work was carried out by the Dresden University of Technology/Dendro-Institut (using methods according to Brasier, 1981, and Kreisel and Schauer, 1987). All the *U. laevis* samples chosen for the test came from areas where DED has been observed over the years with the remaining populations of *U. minor* suffering severely. The areas of disease occurrence were no further away than 1,500 m and the open landscape in between would have made it easy for the elm bark beetle to travel the distance. Soil samples were also taken from 4 plots in order to test for soil pathogens such as *Phytophthora* (Dresden University of Technology/ Dendro-Institut; using methods according to Dick, 1990, and Jung, 1998).

«Hemerobis» (from the Greek word for «tame») is a complementary term for «naturalness» and expresses the degree of human influence on a given area of land, either for a sector of a given landscape (Steinhardt *et al.* 1999) or for an individual location of a plant community (Jalas, 1955; Sukopp, 1976). It ranges from «fully natural» (such as original riparian woodland) and graduates in seven steps to «fully artificial» (such as the heart of a city). Two scales of hemerobis are used to classify the plots and the individual elm locations. The degree of hemerobis has been estimated for both the plot landscape as a whole (macro scale: 20.0 ha) and for the individual elm locations (micro scale: 0.1 ha; Table 1).

The concept of hemerobis is a useful means of easily assessing any given sector of a landscape and comparing it with either the same sector at a different time or with a neighbouring sector. The interpretation is quite simple. For a conservative statement, a difference of 2 degrees of hemerobis is considered relevant. It must be kept in mind, however, that assigning the degree of hemerobis is a professional estimate (or just an educated guess). It denotes a quality and it is not a quantity which can be measured. All in all, the concept of hemerobis can be considered a helpful but rather rough measure of the changes in landscapes.

Table 1. Degrees of hemerobis in two different scales of landscape evaluation (after Sukopp, 1976, and Steinhardt *et al.*, 1999)

Degree	Definition	Marco scale (examples)	Micro scale (examples)
A-hemerobic	Fully natural	Non existent	Non existent
Oligo-hemerobic	Moderately natural	Non existent	Trees in the remains of riparian woodland (Fig. 2)
Meso-hemerobic	Semi-natural	Non existent	Trees along the water line or in small scale woodland
β-eu-hemerobic	Far from natural	Landscape dominated by pastures with light grazing (sheep, goat ...); semi-natural woodland	Groups or single trees in pastures with light grazing (Fig. 5)
α-eu-hemerobic	Far from natural	Landscape dominated by pastures with heavy grazing (horse, cattle ...); deciduous forests	Groups or single trees in pastures with heavy grazing
Poly-hemerobic	Close to artificial	Landscape dominated by ploughland; conifer forests; villages	Single trees in agricultural landscapes, villages, at the edges of forests (Fig. 6)
Meta-hemerobic	Artificial	Landscape dominated by towns, cities, infrastructure	Non existent

Figure 2. A moderately natural riparian wildwood with a row of *Ulmus laevis* along the water line; «Pillnitzer Elbinsel» nature reserve.

The areas of forests and other forms of land use in the plots were calculated using topographical maps and sometimes also aerial photographs.

Other remains of riparian forests were also investigated, though in less detail. Three more or less natural woodlands (the Leipziger Auwald and the Pillnitzer Elbinsel in Saxony (Fig. 2) and the Mittlere Elbe region in adjacent Saxony-Anhalt) particularly allow for comparisons with cultivated floodplain landscapes (Hiebsch, 1960; Müller and Zäumer, 1992; Mackenthun, 2000a; Schmidt, 2002; Roloff and Bonn, 2002) (Fig. 3).

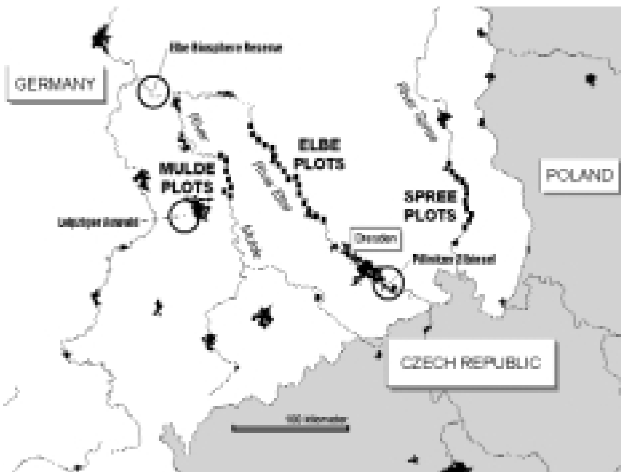

Figure 3. Map of the southern part of East Germany with the three rivers Elbe, Mulde and Spree, the 34 plots along them and the locations of the three semi-natural riparian forests.

Results

Elm numbers

24 of the 34 plots along the three rivers in lowland Saxony contained elms. No elms were found within the five plots located in the large towns and cities which have been classified as meta-hemerobic plots. All the other plots varied between the eu-hemerobic and poly-hemerobic classifications.

We found 176 *U. laevis,* 19 *U. minor,* 3 *U. glabra* and no *U. x hollandica* trees in the 24 plots. The number of *U. laevis* was nearly ten times larger than that of *U. minor*. The lowlands had no natural examples of *U. glabra* known as «Bergulme» in German («mountain elm»). The only three examples were planted in or near villages.

In our survey, we found 198 elms with an over all density of 0.3 per ha. *U. laevis* reached a density of 0.25 per ha and *U. minor* a density of 0.03 per ha in all of the 34 plots which had a total area of 680 ha. If we take into account only those 24 plots in which elms occurred, the density was still only 0.4 per ha.

One typical example of the lack of elms in today's floodplain landscapes can be found in three consecutive plots on the Elbe near the industrial town of Riesa. Only five elms were found in the combined area of 60 ha. The landscape is dominated by ploughland, conifer forests, settlements and transportation infrastructure.

Elm dimensions

On average, *U. minor* trees were much smaller in diameter than *U. laevis* with average diameters of 20.0 cm and 42.3 cm respectively. The largest single *U. minor* measured 80 cm in diameter and stood 12.5 m high. Whereas the largest *U. laevis* was 202 cm in diameter and had a height of 20.0 m.

As can be seen in Fig. 4, *U. minor* more or less only existed in the smallest of the diameter classes. There were a few trees of up to 90 cm in diameter and the larger trees were missing all together. On the other hand, there was a great number of large *U. laevis,* including the one with the measurements mentioned above. At the same time, the first two diameter classes contained fewer *U. laevis* than classes III and IV, which signals a lack of regrowth.

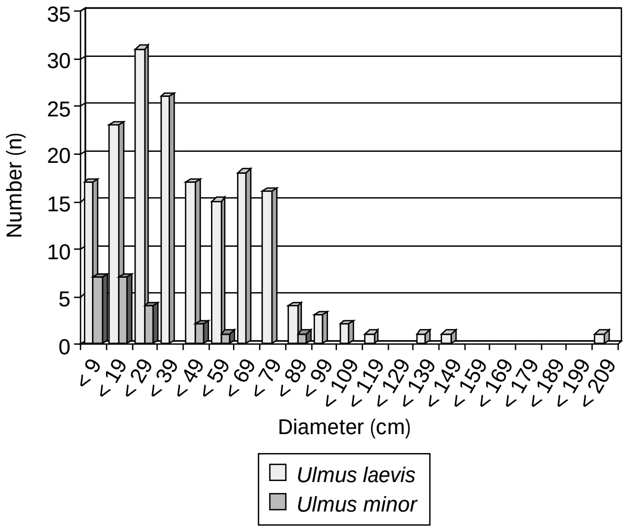

Figure 4. *U. laevis* and *U. minor* trees by diameter (N = 198).

Elm locations

Estimated in the macro scale, all 24 plots containing elms were regarded as being more or less artificial and classified as β-eu-hemerobic to poly-hemerobic. There was only one single β-eu-hemerobic plot which was dominated by meadows with light sheep grazing at the time of the study. The other 23 plots were dominated by modern large scale farming: 10 α-eu-hemerobic (cattle pastures) and 13 poly-hemerobic (ploughland) plots.

Elms occurred in two different types of elm locations within these agricultural landscapes. Type 1: Micro scale habitats with a hemerobis of 2 degrees more natural than the surrounding landscape. For example, the elm habitat was classified as meso-hemerobic while the surrounding landscape in the plot was α-eu-hemerobic. This is the case, for example, when elms occurred together with other wildwood tree and shrub species along the waterline of an old ox-bow embedded in wide stretches of cattle pasture (Fig. 5). Type 2: The elm locations were more or less as unnatural as the surrounding landscape, the difference in the degree of hemerobis was ± 1 or 0. This was the case when a tree stands by itself in a meadow with no natural habitat structures around it (Fig. 6).

Within the 13 poly-hemerobic (ploughland) plots, 91 elms were counted in Type 1 locations which were 2 degrees more natural than the surrounding landscape – these represented more than 45% of all the elms found in the plots. The other 55% of the trees grew in Type 2 locations.

Figure 5. A typical elm landscape with mature *Ulmus laevis* in the «Alte Elbe Kathewitz» nature reserve; a dead arm of the river Elbe is close by.

Crown transparency in elms

In the original study carried out from 1995 to 1999, we very often found large and old examples of *U. laevis* with a high degree of crown transparency. A number of trees were monitored over the period of five years, but no trend could be detected. There was no spatial or specific pattern and the trees did not develop in any single direction over time. This suggests that there is no single external factor which presupposes a decrease in tree vitality.

Various *U. laevis* trees with levels of crown transparency of up to 90% were observed and one tree died slowly over the period of time. At the same time, other elms in the same local population and of the same age were fully leafed and vital. Elms with high degrees of crown transparency did not show the symptoms of DED.

Figure 6. A single *Ulmus laevis* in a plot of 20 ha (plot E 120 at the river Elbe): the elm tree is the only remainder of what once must have been a large wildwood.

A number of fungal organisms were found during the screening for wood pathogens using samples from 18 known examples of *U. laevis*. They belonged to the genera *Alternaria*, *Aspergillus*, *Aureobasidium*, *Candida*, *Hormonema*, *Mucor*, *Paecilomyces*, *Penicillium* and *Trichoderma*. No single species can be held responsible for the development of the crown transparency. As far as any potential pathogens were concerned, no differences were found between the trees with a high degree of crown transparency and the fully leafed trees. No *Ophiostoma ulmi*, *Ophiostoma novo-ulmi* or *Verticillium dahliae* were isolated. Various forms of *Phytium* were isolated in the soil samples, but no species of the genus *Phytophthora* were found. Soil fungi may not be held responsible for the crown transparency in elms.

Discussion

The long term trend of environmental change in river floodplain landscapes started some 6,500 years ago with what is called the Neolithic Revolution. At first, floodplain woodland stands were enhanced with deforestation on loess soils leading to nutrient rich soils in floodplains (Müller and Zäumer, 1992). With the onset of the population growth in the Middle Ages and later during the Industrial Revolution floodplain landscapes were finally turned into areas for modern large scale farming. The growth of cities also resulted in highly artificial townscapes with few natural habitats (Dister, 1985 and 1986; Hermann, 1986; Rackham, 1990; IKSE/MKOL, 1994; Gunkel, 1996; Henrichfreise and Krause, 1997; Speier, 1998; Trémolières *et al.*, 1998; Bonn *et al*., 2002).

This change led to a degree of deforestation unknown in other parts of the country. While, for example, the overall forest cover in Germany is close to one third of the land area (Bundesamt für Naturschutz, 1999), woodland and forests can be reduced to just 2% as in the lowland Elbe floodplain plots investigated in Saxony. There are no reliable figures at hand, but given the enormous loss of woodland it seems to be safe to claim that the elm populations in the floodplains have been reduced at the same scale. For the sake of clarity of argument, we have put the amount of elm loss due to floodplain cultivation at 90%. A more detailed account of what has happened to the river valleys is available in Mackenthun (2002).

We feel that the first massive destruction of elms in Central European floodplains was due to various types of cultivation. Once 90% of the trees had vanished, DED killed another 90% of the elms remaining in little patches of original riparian wildwood (Plachter, 1991). In our opinion, the disease (nearly) finished off what remained after direct human intervention.

Our study clearly demonstrates how low the numbers of elms in today's floodplain landscapes are. On average, there is less than one tree per 2 ha. The number of *U. laevis* is nearly ten times bigger than that of *U. minor*: there is one example of the former in every 4 ha, while of the latter there is only one in every 35 ha. Since the very beginning of modern botany in Saxony, *U. minor* has always been considered to be the most abundant elm species (Wünsche 1869). Some botanists described it as «gemein» («common») in their works (Ficinus and Hennhold, 1838; Reichenbach, 1844). Considering the fact that *U. minor* is more susceptible to DED than *U. laevis*, our findings are no surprise (Sacchetti *et al*., 1990; Schütt *et al*., 1992; Endtmann, 1993; Harris, 1996; Mittempergher, 1996). The biology of *U. laevis* is described in much detail in Müller-Kroehling (2003).

U. minor today is now an endangered species (Jedicke, 1997) both in most German Bundesländer and at the federal level. Its ecological role in floodplain landscapes has been taken over by *U. laevis*, a species which most researchers have given little attention until now. In many parts of Central Europe, if there are any elms at all then *U. laevis* is the mature elm and the characteristic tree of the floodplains today (Fig. 5). Without this species, elms would no longer exist along rivers in any numbers or dimensions worth mentioning.

Some authors claim that the European species of the genus *Ulmus* are close to extinction (Mabey 1996, Müller *et al*,. 2002), but this seems to be an exaggeration. While keeping in mind the low numbers of elms, it is surprising that many still exist against all odds. For Saxony, the total number is estimated to be no less than 100,000 trees with at least 5,000 big, strong, mature elms, most of them being *U. laevis* (Mackenthun, 2003).

The historical view of the hardwood riparian forest was that both *U. minor* and *U. laevis* are dominant trees with the latter probably occurring somewhat less often than the former (Müller and Zäumer, 1992). DED has dramatically changed this. There are parts in Saxony where *U. minor* merely reaches the size of a tall shrub and then succumbs to the disease only to re-grow

Figure 7. From noble hardwoods to shrubs: a group of *Ulmus minor* heavily attacked by Dutch elm disease – near the town of Riesa at the river Elbe.

again and die back again (Fig. 7). The mature *U. minor* has vanished from the floodplain landscapes. Mittempergher (1989) has coined the phrase *Il declino dell' olmo: da latifoglia nobile a cespuglio* («Elm decline: from noble hardwoods to shrubs») to denote this process. Our results strongly support this view. The largest *U. minor* is much smaller than the largest *U. laevis*. On average, the former reaches about half the dimensions of the latter. At the same time, *U. laevis* lacks individuals of smaller size. This may be a result of cattle and sheep grazing which occurred at most of the plots we investigated. The animals destroy much of the regrowth while browsing for food.

If one were to venture to estimate the more or less natural numbers of elms, it would be necessary to look at the larger remains of riparian forests. Two of these forests are situated in Saxony. They have both been protected areas for many decades now, so the impact of the anthropogenic change may be less than in the surrounding areas. One of these is the Leipziger Auwald protected landscape which is a large semi-natural woodland along the Elster and Luppe rivers near Leipzig (Müller and Zäumer, 1992). This forest has a size of about 1,000 ha. It contains 134 elms with a diameter of 30 cm and an enormous number of smaller trees (Fiege, 1993). A conservative estimate would be that there are 15,000 elms in the Leipziger Auwald, which translates into an average of 15 elms per ha. The Pillnitzer Elbinsel nature reserve is in the vicinity of Dresden (Hiebsch, 1969; Fig. 2). This island in the river Elbe has a size of about 15 ha and an elm population of 28 *U. minor* and 234 *U. laevis* (Mackenthun, 2000a). The density of the elms is 17 per ha – a very plausible number. It should be noted again that *U. laevis* occurs ten times more often than *U. minor*, a result which supports the findings from the plots.

One of the largest riparian forests still existing in Germany stands outside Saxony, some 150 km further down the river in the Elbe Biosphere Reserve in Saxony-Anhalt (Roloff and Bonn, 2002). In one small and almost natural plot there, the elm density is very high with 93 trees per 1 ha (Küssner and Wagner, 2002). However, a study of two forest districts in the Mittlere Elbe region, part of the UNESCO approved Elbe Biosphere Reserve, found that even in the riparian broadleaf forests elms are down to 1%, with *Quercus robur* (54%), *Fraxinus excelsior* (13%) and *Populus* (11%) dominating by far (Schmidt, 2002). In comparison, the percentage of *Ulmus* in the Leipziger Auwald was 2% (Gutte and Sickert 1998). So, even if riparian woodland has survived as a broadleaf forest it lacks elms.

When discussing woodlands and forests in floodplains, three facts have to be considered. Firstly, the landscape lacks forests. The floodplain soils are rich in nutrients making them the agricultural soils of choice. In the 34 plots of this study, the forest cover is as low as an average of 15%, while the Elbe river floodplain is at just 2%. Secondly, where forests exist they stand on glacial deposits mainly consisting of sand and gravel. Along the river Spree, with an average forest cover of nearly 40%, the forests are more *Picea abies* and *Pinus sylvestris* plantations. Semi-natural broadleaf woodland in the Spree valley accounts for only 5% of the landscape. Thirdly, elms are lacking in the remains of the original woodlands. *Alnus*, *Fraxinus*, *Populus* and mainly *Quercus* dominate the riparian forests (Schmidt, 2002).

In this study, however, most elms were found in the open landscape, not in woodlands or forests. The floodplains investigated are landscapes of modern large-scale farming with tiny islands of interspersed natural habitat; elms may occur in them. In this case, the elm locations appear to be the small remains of more or less natural elm habitats within the agricultural landscape (Type 1 locations; Fig. 5). In all other cases, it must be claimed that the elm itself represents the remains of a long gone riparian forest (Type 2 locations; Fig. 6). Both types of elm locations are distributed more or less evenly in the floodplain landscapes (45 and 55%, respectively).

As has been shown, some mature *U. laevis* trees have a problem with a high degree of crown transparency. DED is not the cause, as has been demonstrated, though the disease can be found in the area and it has killed most of the *U. minor* trees over the years. *Phytophthora* is also not the cause. So, while we now can exclude this group of soil pathogens as well as *Ophiostoma* and DED as the reasons for high degrees of crown transparency, we still do not know what the problem might be. Some confidence may be taken from the fact that fully leafed trees stand closely beside those with a high degree of crown transparency.

An outlook

If elms are to remain a characteristic feature of floodplain landscapes, the *U. laevis* populations must be secured, protected and enhanced. The planting of *U. laevis* on a large scale seems to be necessary. The Elm Office has taken a first step in choosing a number of mature, fully leafed *U. laevis* as mother trees for propagation. Under the name of 'Torgauer Flatterulme' 'Torgau white elm', a provenance of *U. laevis* has been established for replanting both in the Elbe valley and in other regions with comparable soil and climatic conditions. The Elm Office collaborates with Appel nurseries in Darmstadt and Waldsieversdorf in this field.

Central Europe has been hit by disastrous floods during the last couple of years with Saxony experiencing what has been called the Flood of the Millennium in the summer of 2002. This has given rise to the opportunity of establishing elm forests in floodplains on a reasonable scale. Experts have long voiced the view, now strongly supported by public opinion, that forested areas will largely reduce the impact of heavy and long lasting rainfall and will thus reduce the floods which endanger settlements and infrastructure. *U. laevis* is a good choice for the reforestation of floodplains. *U. minor* should not be forgotten, but given its high susceptibility to DED large scale reforestation with this species is not a reasonable option. Long term efforts must include the planting of tolerant *U. minor* cultivars and the establishment of small populations.

Both aspects of elm protection and elm enhancement are in accordance with European legislation, including the Habitats Directive and the Water Framework Directive, and with global attempts to reclaim land area for conservation and to protect biodiversity (Johnson 1993, Berner 2000, Keitz and Schmalholz 2002). The UNESCO-approved Elbe Biosphere Reserve is an appropriate example of this. The age of elm recovery has only just begun.

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